IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE BOARD OF PATENT APPEALS AND INTERFERENCES

APPLICANT:	Avetik Harutyunyan
APPLICATION NO.:	10/727,699
FILING DATE:	December 03, 2003
TITLE:	Systems and Methods for Production of Carbon Nanostructures
EXAMINER:	Edward M. Johnson
GROUP ART UNIT:	1754
ATTY. DKT. NO.:	23085-07810

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Dated: December 18, 2008 By: / Narinder Banait/
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APPEAL BRIEF

Sir:

This Amended Appeal Brief is hereby timely filed in response to the Notification of Non-Compliant Appeal Brief mailed on December 3, 2008. No fees are believed due.

Real Party in Interest

The subject patent application is owned by Honda Motor Co., LTD.

Related Appeals and Interferences

There are no prior or pending appeals, interferences, or judicial proceedings known to the appellant, the appellant's legal representative, or the assignee, which may be related to, directly affect, be directly affected by, or have a bearing on the Board's decision in this pending appeal.

Status of Claims

Claims 1-5, 7, 8, 10-18, and 38-49 are pending and stand finally rejected in a Final Office Action mailed on December 18, 2007.

Claims 6, 9, 19-37, and 50 were canceled in an amendment filed on October 15, 2007.

Appellant appeals from the final rejection of all the finally rejected claims 1-5, 7, 8, 10-18, and 38-49, which are set forth in an appendix attached hereto.

Status of Amendments

Applicant did not amend the claims after the Final Rejection.

Summary of Claimed Subject Matter

Appellants' invention provides methods for the large scale continuous production of carbon nanostructures, such as single-walled carbon nanotubes (Spec. page 5, lines 12-21, Figure 3). The applicants' invention provides metal particles having controlled particle size and/or diameter supported on non-carbon containing powdered oxide supports. The resulting metal nanoparticles are used as catalyst for the growth of carbon nanotubes. The supported catalyst nanoparticles are entrained in a gas and delivered into the reaction chamber as an aerosol and a

carbon precursor gas is introduced into the reaction chamber (Figure 2, **130** and **200**). The carbon nanotubes thus produced are collected and purified (Spec. Page 9, lines 13-20, Figure 4).

More specifically, independent claim 1 recites a method for synthesizing carbon nanostructures (Spec. page 5, lines 12-21), the method comprising:

providing a catalyst of metal nanoparticles (Spec. page 5, lines 12-21, Figure 2, **130**), wherein the catalyst is supported on a powdered oxide substrate (Spec. page 5, lines 12-21) having a particle size of 0.5 μm to 5 μm (Spec. page 16, line 21 to page 17, line 9);

entraining the catalyst in an inert gas (Spec. page 20, line 21 to page 21, line 7); and

exposing the entrained catalyst to a carbon precursor gas (Figure 2, **140)** at a temperature sufficient to form carbon nanostructures (Spec. page 21, line 8 to page 22, line 2, Figure 2, **200**), wherein the carbon nanostructure is single-walled carbon nanotubes (Spec. page 5, lines 12-21, Figure 4).

Independent claim 38 recites a carbon nanotube structure produced by the process of (Spec. page 6, lines 1-10) :

entraining a catalyst in an inert gas (Spec. page 20, line 21 to page 21, line 7, Figure 2, **130**), wherein the catalyst is a metal (Spec. page 12, line 17 to page 13, line 6) supported on a powdered oxide substrate (Spec. page 5, lines 12-21), wherein the metal is selected from the group consisting of iron, nickel, molybdenum and cobalt, or mixtures thereof (Spec. page 13, lines 7-15), and the powdered oxide substrate selected from the group consisting of Al_2O_3, SiO_3, MgO and zeolites (Spec. page 16, line 21 to page 17, line 9);

exposing the entrained catalyst to a precursor gas at a temperature sufficient to form carbon nanotube structure (Spec. page 21, line 8 to page 22, line 2, Figure 2, **200**); and collecting the synthesized carbon nanostructures (Spec. page 5, lines 12-21, Figure 2, 220), wherein the carbon nanostructure is single-walled carbon nanotubes (Spec. page 5, lines 12-21, Figure 3).

<u>Grounds of Rejection to be Reviewed on Appeal</u>

Whether claims 1-3, 5, 7, 8, 10-18, 38-39, and 41-49 are unpatentable under 35 U.S.C. §103(a) U.S. Patent No 4,663,230 to Tennent.

Whether claims 4 and 40 are unpatentable under 35 U.S.C. §103(a) over U.S. Patent No 4,663,230 to Tennent further in view of U.S. Patent No. 6,221,330 to Moy *et al.*

<u>Argument</u>

<u>Rejection of claims 1-3, 5, 7, 8, 10-18, 38-39, and 41-49 under 35 U.S.C. §103(a)</u>

On pages 2-4 of the Final Office Action mailed December 18, 2007, claims 1-3, 5, 7, 8, 10-18, 38-39, and 41-49 were rejected under 35 U.S.C. §103(a) as allegedly being unpatentable over U.S. Patent No 4,663,230 to Tennent (Tennent). The Examiner stated that Tennent discloses a method for making nano-sized carbon fibers by providing a catalyst nanoparticle and exposing to carbon containing gas to form fibers. The rejection was maintained in an Advisory Action mailed April 22, 2008. This rejection is traversed.

This rejection is clearly in error because Tennent does not teach supporting the catalyst on a powdered oxide substrate nor does it teach entraining the supported catalyst in an inert gas. An element of the independent claims 1 and 38 is supporting the catalyst on a powdered oxide substrate and entraining the supported catalyst in an inert gas. Thus, Tennent does not disclose all the elements of the Applicants' claims.

Tennent at column 6, lines 13-20 states that the catalyst is deposited on refractory supports, such as alumina, carbon, quartz, silicates, and aluminum silicates. At column 6, lines 20-22, Tennent states that the refractory supports should be thin films or plates which can be easily moved into and out of the reactor. Tennent's catalyst is thus placed on a film or plate made of alumina, carbon silicates, and the like, and is not supported on a powdered oxide substrate. The applicants' independent claim 1 recites that the catalyst is supported on a powdered oxide substrate having a particle size of 0.5 μm to 5 μm. At no time does Tennent teach this limitation of the independent claim.

The Examiner, at page 4 of the Final Office Action, states that Tennet discloses "nano-sized" carbon fibers, "which would at least suggest a range of 0.5-5 μm." The Examiner is clearly wrong since the size limitation in the applicants' claims refers to the size of the catalyst on the powdered oxide support, while the size limitation in Tennent refers to the product formed. Tennent does not disclose that the supported catalyst is nano-sized. Instead, Tennent discloses that the catalyst is supported on thin film or plate supports, which are not nano-sized. The Examiner has incorrectly read the nano-sized carbon fibers disclosed by Tennent to mean that this suggest a range of 0.5-5 μm for the catalyst used to make the product.

The Examiner acknowledges that Tennent fails to disclose entraining the catalyst in inert gas, but states that it would have been obvious to one of ordinary skill in the art because Tennet discloses contacting in the presence of hydrogen (column 4, lines 4-5), therefore it would have been obvious to entrain the catalyst in inert gas. The applicants disagree. The hydrogen gas used by Tennent is not an inert gas. Hydrogen gas is used in these reactions to activate the catalyst. The hydrogen gas and high temperature reduce the catalyst in preparation for the synthesis of fibers in the case of Tennent and single-walled carbon nanotubes in the case of the applicants. Thus, the Examiner has incorrectly asserted that hydrogen gas, as used by Tennent, is an inert gas. The use of a reactant gas to activate the catalyst does not suggest that the catalyst could be entrained in an inert gas.

Further, a person of skill in the art is not likely to try to entrain a film, a plate, or a boat made from alumina, carbon, quartz, silicates, and aluminum silicates (disclosed by Tennent) using hydrogen gas or in an inert gas. Tennent in Examples 11-33 discloses the synthesis of the fibrils. In all of these examples, the catalyst is transferred to a refractory support which is then placed in the reaction chamber; the catalyst is not entrained in an inert gas by Tennent. For example, Example 11 states that the "[c]atalyst prepared according to the method of Example 1 was ultrasonically dispersed in water and transferred to a ceramic boat. The boat was placed in the center of a 1" Vycor™ tube in an electric furnace at room temperature." Thus, the catalyst is placed in a ceramic boat, and not entrained in an inert gas. The Applicant suggests that a 1" Vycor™ tube into which is placed a ceramic boat containing the catalyst would be too heavy to entrain in a gas.

Finally, the independent claims 1 and 38 recite that the nanostructure is single-walled carbon nanotubes. Tennent discloses the synthesis of carbon fibril and not single-walled carbon nanotubes. Thus, Tennent does not disclose all the elements of the applicants' claims as amended. Therefore, a prima facie case of obviousness is not made.

The rejection of claims 1-3, 5, 7, 8, 10-18, 38-39, and 41-49 cannot stand.

<u>Rejection of Claims 4 and 40</u>

Claims 4 and 40 were rejected under 35 U.S.C. §103(a) as allegedly being unpatentable over Tennent and in view of U.S. Patent No. U.S. Patent No. 6,221,330 to Moy *et al.* (Moy).

This rejection is clearly in error because the Moy reference teaches away from combining it with Tennent to obtain the catalyst used by the applicant in his invention. An element of the independent claims 1 and 38 is the metal catalyst is supported on a powdered oxide substrate. In contrast, Moy clearly states that the catalyst should be not be supported. Thus, there is no motivation to combine Tennent with Moy.

Moy at column 2, lines 65-67 states that "supported metal catalysts are inherently disadvantageous, as the support is necessarily incorporated into the single-walled carbon nanotube formed therefrom." Further, at column 4, lines 4-5, Moy states that their method to form single-walled carbon nanotubes uses <u>unsupported catalysts</u>. Thus, Moy teach away from using the supported catalysts of Tennent to synthesize single-walled carbon nanotubes. Therefore, a skilled artisan would not be motivated to combine Tennent with Moy.

The rejection of claims 4 and 40 cannot stand.

Summary

For the foregoing reasons, Appellant respectfully submit that the rejection of claims 1-3, 5, 7, 8, 10-18, 38-39, and 41-49 is clearly erroneous. Reversal of the final rejection of claims 1-3, 5, 7, 8, 10-18, 38-39, and 41-49 is respectfully requested.

Respectfully submitted,

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Claims Appendix

The status of the claims is as follows:

1. A method for synthesizing carbon nanostructures, the method comprising:

providing a catalyst of metal nanoparticles, wherein the catalyst is supported on a powdered oxide substrate having a particle size of 0.5 μm to 5 μm;

entraining the catalyst in an inert gas; and

exposing the entrained catalyst to a carbon precursor gas at a temperature sufficient to form carbon nanostructures, wherein the carbon nanostructure is single-walled carbon nanotubes.

2. The method of claim 1, wherein the catalyst is a metal selected from the group consisting of iron, nickel, molybdenum and cobalt, or mixtures thereof.

3. The method of claim 2, wherein the metal is iron.

4. The method of claim 2, wherein the metal is molybdenum.

5. The method of claim 1, wherein the catalyst has a particle size between 3 nm to 7nm or about 5 nm to 10 nm.

7. The method of claim 6, wherein the powdered oxide substrate is selected from the group consisting of Al_2O_3, SiO_3, MgO and zeolites.

8. The method of claim 7, wherein the powdered oxide substrate is Al_2O_3.

10. The method of claim 1, wherein the inert gas is selected from the group consisting of argon, helium, nitrogen, or hydrogen.

11. The method of claim 10, wherein the inert gas is argon.

12. The method of claim 1, wherein the carbon precursor gas is selected from the group consisting of methane, ethane, propane, ethylene, propylene, and carbon dioxide.

13. The method of claim 12, wherein the carbon precursor gas is methane.

14. The method of claim 1, further comprising another gas.

15. The method of claim 14, wherein the other gas is selected from the group consisting of hydrogen, helium, argon, neon, krypton and xenon or a mixture thereof.

16. The method of claim 15, wherein the other gas is a mixture of hydrogen and argon.

17. The method of claim 1, wherein the temperature is less than 1000 ºC.

18. The method of claim 17, wherein the temperature is about 800 ºC to 1000 ºC.

38. A carbon nanotube structure produced by the process of :

entraining a catalyst in an inert gas, wherein the catalyst is a metal supported on a powdered oxide substrate, wherein the metal is selected from the group consisting of iron, nickel, molybdenum and cobalt, or mixtures thereof, and the powdered oxide substrate selected from the group consisting of Al_2O_3, SiO_3, MgO and zeolites;

exposing the entrained catalyst to a precursor gas at a temperature sufficient to form carbon nanotube structure; and

collecting the synthesized carbon nanostructures, wherein the carbon nanostructure is single-walled carbon nanotubes.

39. The process of claim 38, wherein the metal is iron.

40. The process of claim 38, wherein the metal is molybdenum.

41. The process of claim 38, wherein the powdered oxide substrate is Al_2O_3.

42. The process of claim 38, wherein the powdered oxide substrate has a particle size of 0.5 μm to 5 μm, and the metal has a particle size between 3 nm to 10 nm.

43. The process of claim 38, wherein the inert gas is selected from the group consisting of argon, helium, nitrogen, or hydrogen.

44. The process of claim 43, wherein the inert gas is argon.

45. The process of claim 38, wherein the reactant gas is selected from the group consisting of methane, ethane, propane, ethylene, propylene, and carbon dioxide.

46. The process of claim 45, wherein the reactant gas is methane.

47. The process of claim 45, further comprising another gas selected from the group consisting of hydrogen, helium, argon, neon, krypton and xenon or a mixture thereof.

48. The process of claim 47, wherein the other gas is a mixture of hydrogen and argon.

49. The process of claim 38, wherein the temperature is less than 1000 ^{o}C.

Evidence Appendix

None.

Related Proceedings Appendix

None.